Shell Lake Fishery Survey, Washburn County, Wisconsin 2013

MWBIC 2496300

Craig Roberts & Jamison Wendel

Senior Fisheries Biologist

Wisconsin Department of Natural Resources

Northern Region – Spooner

January 2015

Executive Summary

A comprehensive survey of Shell Lake (Washburn County) was conducted during 2012-2014 by the Wisconsin Department of Natural Resources. The primary objective of this study was to assess the status of the walleye population, as well as sport and tribal exploitation of walleye on Shell Lake. Secondary objectives were to assess muskellunge, largemouth and smallmouth bass, northern pike, and panfish populations.

The 2013 adult walleye population estimate on Shell Lake (0.6 fish/acre) was much lower than Ceded territory averages. However, large 2011 and 2013 year classes should help the Shell Lake walleye population return to near average levels. Muskellunge were at low densities and likely have multiple factors influencing survival to trophy sizes. Smallmouth bass provide an excellent fishery with 45% of the sample being above the minimum length limit. The largemouth bass population in Shell Lake has increased dramatically since 1999. Bluegills have a desirable size structure and provide good fishing opportunities on the lake.

Since 1999, angler projected pressure dropped by 59%. Walleye angling dropped by 3.15 angler hours/acre and represented the largest drop in angler pressure. Muskellunge angling dropped by 1.13 angler hours/acre. The hard 2013-2014 winter also played a role in the decreased overall fishing pressure.

Management recommendations include: 1) Monitor the walleye population and explore new regulations if recruitment becomes poor. 2) Monitor the smallmouth and largemouth bass fishery for responses the no minimum size limit. 3) Monitor impacts of liberalized bass regulations on panfish populations. 4) Monitor the muskellunge population and explore changes to stocking. 5) Continue consumptive opportunities for northern pike. 6) Protect and enhance limited fish habitat.

Introduction

Shell Lake is a soft-water seepage lake in southeast Washburn County. The lake's shoreline is primarily privately owned and highly developed. Shell Lake is 2,513 acres with a maximum depth of 36 feet and mean depth of 23 feet. Invasive species present in Shell Lake include curly-leaf pondweed *Potamogeton crispus*, banded mystery snail *Viviparus georgianus*, and Chinese mystery snail *Bellamya chinensis*.

Shell Lake is a clear-water, mesotrophic lake. Trophic State Index (TSI) is an index for evaluating trophic state or nutrient condition of lakes (Carlson 1977; Lillie et. al. 1993). TSI values can be computed using water clarity (secchi disk measurements), chlorophyll-a, and total phosphorus values. TSI values represent a continuum ranging from very clear, nutrient poor water (low TSIs) to extremely productive, nutrient rich water (high TSIs). The data on Shell Lake (WDNR 2013) indicate the nutrient conditions were mesotrophic (moderate productivity) when considering secchi disk, total phosphorus and chlorophyll-a TSI indices. Between 1987 and 2011, the mean secchi TSI value was 42.52 (S.D. = 3.75) from samples taken near the deep hole of Shell Lake.

Gamefish species present in Shell Lake include largemouth bass *Micropterus salmoides*, smallmouth bass *M. dolomieui*, walleye *Sander vitreus*, muskellunge *Esox masquinongy*, and northern pike *E. lucius*. Panfish species include bluegill *Lepomis macrochirus*, black crappie *Pomoxis nigromaculatus*, pumpkinseed *L. gibbosus*, yellow perch *Perca flavescens*, and rock bass *Ambloplites rubestris*. Other fish species common in Shell Lake include bowfin *Amia calva*, and white sucker *Catostomus commersoni*.

Recent fisheries management activities on Shell Lake have focused on surveys and fish stocking. Since 1997, muskellunge have been the only fish species stocked into Shell Lake

(Appendix Table 1). During this survey, all of the standard statewide fishing regulations applied to Shell Lake, except for a no minimum length limit on walleye (Appendix Table 2).

Numerous surveys primarily targeting walleyes have been conducted by Wisconsin DNR and Great Lakes Indian Fish and Wildlife Commission in recent years. Since 1992, 19 fall surveys assessing juvenile walleye recruitment have been conducted on Shell Lake by either Great Lakes Indian Fish or Wildlife Commission or Wisconsin Department of Natural Resources staff. The only years Shell Lake was not assessed for juvenile walleye recruitment were 1996, 1997, 2000, and 2007. The last comprehensive survey of Shell Lake was conducted in 1999. The primary objective of this study was to assess the status of the walleye population, as well as sport and tribal exploitation of walleye on Shell Lake. Secondary objectives were to assess muskellunge, smallmouth and largemouth bass, northern pike, and panfish populations.

Methods

Field Sampling

Shell Lake was surveyed during 2012-2014 following the Wisconsin Department of Natural Resources treaty assessment protocol (Cichosz 2014). Spring sampling utilized fyke nets and electrofishing to assess gamefish and panfish populations. Beginning with the gamefishing opener in May, 2013, a creel survey (both open water and ice) was conducted. Summer mini-fyke netting was used to sample juvenile and nongame fish species. Fall electrofishing targeted young-of-year (YOY) walleye.

Sampling for muskellunge was conducted over two years to estimate adult (fish greater than 30 in) population size (Hanson 1986). The first phase of the survey was initiated in 2012 with fyke nets (4 x 5 ft frame) set on 31 March. Nets were set at areas with anticipated high

concentrations of spawning muskellunge. Nets were removed on 17 April, with a total effort of 162 net nights. Northern pike were also sampled during this portion of the survey.

Fyke nets were set again in 2013 soon after ice out on 09 May. Nets were checked daily and set at areas expected to contain high concentrations of spawning walleye and muskellunge. Nets were removed on 15 May, with a total effort of 99 net nights. After removal of nets, the entire shoreline of Shell Lake was sampled with an electrofishing boat on 15 May for the adult walleye recapture run.

A population estimate for both largemouth and smallmouth bass took place in 2013. All bass captured during spring fyke netting and the walleye recapture run were marked. Daytime electrofishing was conducted on 28 and 29 May and 03 and 10 June to increase the number of marked fish at large. The recapture was conducted on 13 June where both bass species were sampled over the entire shoreline. In addition to bass, panfish were collected in three, 1/2 mile index stations.

All walleyes, muskellunge, northern pike (2012 survey only), smallmouth bass, and largemouth bass captured during the spring portion of the survey were measured to the nearest 0.5 in and given the appropriate fin clip (Appendix Table 3). Sex was determined for walleyes, muskellunge, and northern pike by the presence of gametes.

Five fyke nets were set on 19 June targeting panfish. These nets were set overnight for a total effort of five net nights. This sampling supplemented electrofishing data collected 13 June.

Six mini-fyke nets (3 x 3 ft frame) were set on 21 August and run for one night. Juvenile and nongame fish species were targeted during this survey. Small-mesh panels on the front frame of the nets were used to exclude larger fish and turtles.

The final component of the on-the-water sampling consisted of a fall electrofishing run on 25 September. During this survey, only walleye <12.0 in and muskellunge <20.0 in were targeted and collected over the entire shoreline.

Age and Statistical Analysis

For age analysis, scale samples were removed from walleyes and largemouth bass less than 12 in, while dorsal spines were removed from larger walleyes, smallmouth bass, and largemouth bass. Muskellunge age determinations were not included in this report due to low accuracy in interpreting scale annuli for muskellunge 3-10 years of age (Fitzgerald et al. 1997). Age interpretations on northern pike were not conducted due to the unreliability and difficulty of determining annuli. Casselman (1990) found this to be due to irregular growth and resorption or erosion on the midlateral region. The descending limb of a catch curve regression was used to estimate smallmouth bass total annual mortality (Ricker 1975). Muskellunge analysis focused on adult fish greater than 30 in.

Size structure quality of species sampled was determined using proportional stock density (PSD) indices (Neumann et al. 2013). The PSD value for a species is the number of fish of a specified length and longer divided by the number of fish of stock length or longer, the result multiplied by 100 (Appendix Table 4). Catch per Unit Effort (CPE) was calculated as the number of fish captured divided by the appropriate unit of sampling effort for that species.

Creel Survey and Exploitation Estimation

A creel survey was conducted on Shell Lake from 4 May 2013 to 2 March 2014. The survey took place in both open water and ice conditions. No data was collected during

November during the early ice period when ice is unsafe for fishing. The survey used a random stratified roving access design (Beard et al. 1997). Angler directed effort (hrs), catch, harvest, and mean length of harvested fish was the data collected during the survey. The creel survey also recorded the number of marked fish harvested. Using this data, recreational exploitation (walleye, largemouth bass, smallmouth bass) can be estimated by dividing the number of marked fish (spring fyke-netting and electrofishing) divided by the estimated number of marked fish harvested during the creel survey (Ricker 1975). Tribal exploitation was calculated using the number of walleye harvested in the spring divided by the total walleye population estimate (Ricker 1975).

Results

Early Spring Fyke-Netting and Electrofishing

Walleye. The 2013 adult walleye population estimate on Shell Lake was 1,490 fish (CV = 0.36), the lowest estimated abundance of any previous survey (Figure 1). The estimated density (0.6 fish/acre) was below the average density of other ceded territory walleye lakes where natural reproduction was the primary source of recruitment (4.0 fish/acre). Catches per effort (CPE) were 3.75/net night for fyke nets and 16.0/mile for the recapture run.

Adult walleyes captured in the 2013 spring survey ranged from 11.2 - 21.7 in (Figure 2). Mean lengths of male and female walleyes were 16.7 (S.D. = 1.1) and 19.0 in (S.D. = 1.1), respectively. Walleye were larger in 2013 survey than in 1999 (Figure 3). The proportional stock density (PSD) and proportional stock density of preferred size (PSD-P) walleyes captured during spring fyke netting was 99.5 and 3.2, respectively.

Growth rates for both male and female walleyes on Shell Lake were below regional averages (Figures 4 and 5). Catch curve analysis and von Bertalanffy growth curves of adult walleyes were not estimated as the age structure was dominated by one year class (Table 1A and 1B).

Northern pike. A total of 340 northern pike, ranging in length from 10.0-39.0 in were captured during 2012 spring fyke netting surveys (Figure 6). Mean lengths of male and female northern pike captured in 2012 were 19.8 in (S.D. = 1.6) and 22.6 in (S.D. = 4.4), respectively. PSD and PSD-P values for northern pike sampled during spring netting in 2013 were both comparable to previous surveys (Table 2). Catch rates for northern pike decreased from 7.4/net night in 2002 to 2.1/net night in 2012. The higher catch rate for northern pike coincided with higher water levels on Shell Lake (2002=1224 avg. ft above sea level; 2012=1218 avg. ft above sea level).

Muskellunge. The 2013 adult (> 30 in) muskellunge population was estimated at 70 fish (C.V. = 0.19) and a density of .03 fish/acre. This estimate is a decrease from the 2003 estimate of 155 fish (C.V. = 0.41). Adult fish ranged in length from 30.0 to 49.8 in. Male and female muskellunge averaged 33.1 in (S.D. = 4.9) and 43.3 in (S.D. = 4.6), respectively. Muskellunge had a larger size structure during 2013 compared to the 2002-2003 survey (Figure 7). Eleven percent of the muskellunge were greater than 40 in in 2002-2003, while 40% were greater than 40 in in 2012-2013. A total of 19 muskellunge between 9-14 inches were also captured during spring fyke netting on Shell Lake in 2012. These fish were likely were stocked in fall 2011, suggesting good overwinter survival. Catch rates for adult muskellunge decreased slightly from 0.3/net night in 2002-2003 to 0.2/net night in 2012-2013.

Late Spring Fyke Netting, Electrofishing, and Mini-fyke Netting

Smallmouth bass. The 2013 smallmouth bass population was estimated at 5,047 fish (CV = 0.15) and a density of 2.0 fish/acre. This estimate is similar to the 1999 population estimate of 4,921 fish (1.9 fish/acre). A total of 408 smallmouth bass were collected on 13 June ranging from 3.5 – 18.0 in. The catch rate increased to 40.0 fish/mile compared to 1999 (36.7 fish/mile). Mean length for smallmouth bass was 12.7 in (S.D. = 2.4), similar to 1999 (12.8 in; S.D. = 1.8). PSD and PSD-P were excellent at 71 and 45, respectively. Numbers of fish sampled over 15 in increased from the 1994 and 1999 surveys. Age-3 and age-6 smallmouth bass dominated the population in 2013, which could impact the mean length and mortality estimates (Figure 8). Growth rates were near/above Northern Region and Statewide averages until Age-6. Older fish grew slower than Northern Region averages, but were similar to other Washburn county seepage lakes (Figure 9). The total annual survival rate was 72% (Figure 10).

Largemouth bass. The 2013 largemouth bass population on Shell Lake was estimated at 3,354 fish (CV = 0.29). The estimated density of largemouth bass was 1.3 fish/acre. A total of 152 largemouth bass were collected on 13 June that ranged in length from 4.0-16.0 in. Largemouth bass catch increased from 0.6 fish/mile (1999) to 15.9 fish/mile (2013). Mean length for largemouth bass was 11.0 in (S.D. = 3.2). PSD and PSD-P were 52 and 9, respectively. Largemouth bass grew to 10.9 in at Age-3, 1.9 in above the regional average. At age-7 growth had slowed to 14.2 in, about 1.8 in below the regional average. Shell Lake largemouth bass growth was similar to other Washburn and Burnett county seepage lakes (Figure 11).

Panfish. A total of 365 bluegills (mean length = 5.8, S.D. = 0.6) were captured during the 19 June fyke net sampling on Shell Lake. The catch rate was 60.8 fish/net night. Bluegill had a PSD of 51 and PSD-P of 7, a large decrease from 1999 (PSD=88; PSD-P=16) (Figure 12).

However, these values still fall within the recommended PSD range for bluegill in a balanced fishery (Neumann et al. 2013). The second most abundant panfish captured was rock bass at 22.5 fish/net night (mean length = 9.4 in; S.D. = 0.4). Pumpkinseeds were captured at a rate of 10.7 fish/net night (mean length = 6.6; S.D. = 1.4). Other panfish species present in lower abundances included black crappie and yellow perch.

Nongame and juvenile gamefish. A total of 11 species were captured during the 2013 mini fyke netting survey (Table 3). The species diversity decreased by nine species from the 2009 survey. Yellow perch, bluegill, and smallmouth bass were the most abundant species in 2013. All potential forage species decreased or were missing from the 2013 sample except yellow perch and spottail shiner *Notropis hudsonius*.

Fall Electrofishing

Catch rates of Young of Year (YOY) walleye were well above average (18.2/mile; Cichosz 2014) for 2013 at 117.7 fish/mile. The average catch rate of YOY walleye in surveys conducted by both Great Lakes Indian Fish and Wildlife Commission and Wisconsin DNR crews between 1992 and 2013 was lower at 31.1 fish/mile (S.D. = 32.5, N = 19; (Figure 13)). Eight juvenile muskellunge from 11.0 – 12.6 in were also collected during fall survey.

Creel survey and Exploitation

A total of 15,066 angler hours (5.8 hr/acre) were spent on Shell Lake from May 2013 to March 2014. The total projected pressure has decreased from the previous two surveys (Table 4). Open water fishing accounted for 97% of the angler fishing pressure at 5.6 hr/acre, while ice fishing only accounted for 3% or 0.2 hr/acre (Table 4). Anglers spent the most time fishing for

smallmouth bass (30%), followed by walleye (17%), and bluegill (15%) in 2013. This is a shift from previous surveys where walleye was the most targeted species (Figure 14). Bluegill were the most harvested fish (1,613), followed by rock bass (841), and smallmouth bass (605) in 2013. Harvest rates have also changed with an increase in bass harvest and decrease in walleye harvest (Figure 15).

Recreational exploitation for walleye was estimated at 3.2%, while tribal exploitation was estimated at 17.4%. The 2013 total exploitation rate for walleye was estimated at 20.6%. This rate is above previous surveys conducted in 1999 and 1994 (Table 5). Recreational exploitation was estimated at 19.6% for Smallmouth Bass and 7.8% for Largemouth Bass in 2013. No tribal harvest was recorded for either bass species. Muskellunge had 0% recreational exploitation rate and an 8.8% tribal exploitation rate (WDNR treaty unpublished data).

Discussion

The sport fishery of Shell Lake has undergone some substantial changes in the past 30 years. A 1977 survey (Johannes 1978) found walleye, smallmouth bass, and black bullhead as the most sought after species in Shell Lake. Based on the 2013 creel survey, smallmouth bass, panfish (mostly bluegill), and walleye are now where anglers place their efforts.

Historically, walleye have undergone erratic recruitment patterns on Shell Lake (J.H. Klingbiel, Wisconsin DNR unpublished data). However, walleye densities remain lower than they were in the past. The walleye density in 1977 was 4.5 fish/acre (Johannes 1978), which is double the highest density recorded in the past 23 years (2009; 1.9 fish/acre). Similar declines in walleye densities have been seen in many other waterbodies in northwestern Wisconsin (Benike 2005; Benike 2010; Cole 2014).

Despite the low population estimate, the walleye population in Shell Lake is expected to rebound in the next few years. The 2013 (117.6 fish/mile) and 2011 (88.4 fish/mile) year classes represent the first and second highest recorded catches of YOY walleye per mile since 1990.

Anglers adjusted their behavior to the lower walleye population level in 2013 by fishing for other species. Smallmouth bass had the most fishing effort and panfish were the most harvested in 2013. However, the creel estimates may have been affected by the harsh winter of 2013-2014. The colder than average temperatures (5.2 – 7.8 degrees F below average) and increased snowfall amounts (10.5 – 21.7 in above avg.; NOAA 2014) made winter conditions difficult and likely kept many ice anglers indoors from December to March. Walleye ice fishing effort on Shell Lake has been higher in the past (1994=5,359 hrs; 1999=2,011 hrs) than the 2013-2014 winter (488 hrs).

The smallmouth bass population has changed little since 1999. Overall, the lake holds an excellent smallmouth bass population. The size structure is good with 45% of smallmouth bass collected being legal to harvest. With walleye abundance low, anglers spent more time fishing for smallmouth bass in 2013. As a result there was a high rate of recreational exploitation at 19.6% and a 16.0 in average length of fish harvested. It is unknown if this trend will continue as the recent walleye year classes become available to angling in the lake.

Muskellunge numbers in Shell Lake have undergone a substantial decrease since 2003. A 55% population decrease occurred with musky over 30 in. Stocking rates have varied from 0.47 to 1.0 fish/acre since 1998. The lowest stocking rates occurred in 2002 and 2004 at 0.47 and 0.51 fish/acre. In northern Wisconsin, it takes 7 to 9 years to reach 34 in (Margenau and Aveallemant 2000). One fish was collected in the 34 to 36 in range suggesting the lowered stocking rates may have impacted adult recruitment in Shell Lake. Shell Lake adult muskellunge

density has fallen well below the average for northern Wisconsin lakes (0.42 fish/acre in Margenau and Aveallemant 2000).

The only source of muskellunge fishing mortality in 2013 was from tribal spearing which accounted for 10 fish harvested, while zero fish were harvested recreationally. The tribal harvest numbers have stayed consistent since the 1990s and have a long term average of 11 fish/year. Though tribal harvest is low, even minimal harvest over time can cause declines in muskellunge populations and potential for large fish (Faust 2011). In addition to stocking variation and tribal harvest, natural mortality likely plays a role in lowered abundance of adult muskellunge. Wendel (2011; 2013) attributes the lower densities of muskellunge to changes in the fish community and prey abundance. The lowered lake levels may have an impact on muskellunge survival by reducing available vegetation for juvenile stocked fish. Hanson and Margenau (1992) documented this importance on aquatic vegetation in northwest Wisconsin for this life stage.

Shell Lake has generally maintained a low density muskellunge fishery, where they are a secondary gamefish to walleye and smallmouth bass at this time. The 2013 creel survey revealed a low amount of fishing effort for muskellunge (4.7%), which was the lowest amount of effort given for gamefish in the creel survey. Historically, Shell Lake was known as a trophy fishery and received pressure for this reason. In 1994, muskellunge were third in angler effort on Shell Lake (12.9%) and average length of fish caught was 43.5 in. Though angler effort was low for muskellunge in 2013, the opportunity for these trophy fish may be available once again with higher proportions of muskellunge over 40 in.

Northern pike size structure has remained relatively stable. However, catch rates for northern pike have dropped since 2002. The lowered catch is likely tied to lake levels as flooded vegetation was probably more abundant in the early 2000s. Drier periods have resulted in

lowered lake levels, less vegetation, poor pike recruitment, and therefore less fish in the lake. Shell lake still has a fair number of quality sized fish (≥ 21 in), but lacks numbers of fish over 28 inches. Harvest and effort for northern pike has dropped since 1999.

The largemouth bass population has changed dramatically in the past 15 years in Shell Lake. In 1999, only 18 fish were captured in an attempt to do a population estimate and few fish were marked in multiple sampling events. In contrast, 2013 population abundance was 3,354 fish with 414 fish handled during the population estimate. These changes suggest a large increase in largemouth bass population in Shell Lake. Most largemouth bass are in the south bay, which has more aquatic vegetation than the rest of the lake (WDNR unpublished data). Despite the population increase, angler exploitation is below that of smallmouth bass at 7.8%.

Good numbers of panfish were present in Shell Lake and anglers targeted them in 2013 (65% of harvest). Bluegill were the most pursued fish despite a drop in PSD-7 of 36. Good growth exists in Shell Lake. All ages of bluegill observed had a mean length above the Washburn/Burnett County and Northern Region average length-at-age (Figure 16). This growth pattern should replenish the quality sized bluegill in the lake. Large rock bass are also present in Shell Lake and provide another opportunity for anglers.

Non-game/juvenile gamefish sampling revealed differences between the 1999 and 2013 mini-fyke net catches. Most notable is the drop in species present. The recent surge in YOY walleye and increases in largemouth bass population may explain the drop in forage abundance and diversity. Sampling date may also have impacted the diversity of species present with the 1999 sample (July) occurring a month earlier than the 2013 sample (August). Seasonal variations in abundance of young non-game species (i.e. suckers, minnows) may contribute to

the differences. Abundant YOY yellow perch will help support recent large year classes of walleye.

Conclusions and Management Recommendations

1. Walleye have been the primary sportfish in Shell Lake and remain the interest of management. Though abundance was low, three years of good recruitment should boost the population levels. The one fish over 14 in regulation was implemented in 2015 as part of the new Ceded Territory three bag rule. This size limit should allow a greater number of walleye to reach reproductive size and age.
2. A no-minimum length limit (2016) on largemouth bass should help to reverse the recent increases in abundance similar to what has occurred on other area lakes. This harvest friendly regulation would help keep largemouth bass densities lower and improve the size structure on Shell Lake. bh
3. Consideration should be given to placing smallmouth bass under a separate length regulation if exploitation remains high.
4. Catch rates of large bluegill are good in Shell Lake. Impacts to the bluegill population with a no-minimum length limit on basses should be evaluated during the next survey in 2018.
5. Muskellunge are at very low densities. Consideration should be given to modifying the number of muskellunge stocked and/or the size of fish stocked in Shell Lake.
6. Northern pike densities are at moderate levels and should provide good consumptive opportunities for anglers. Numbers of very large fish may be limited by lack of optimal habitat and prey items.

7. Critical fish habitat in Shell Lake needs to be protected and enhanced where possible. Efforts should be made to work with the Shell Lake Association and local angler groups stressing the importance of protecting critical habitat and water quality.
8. Efforts to increase habitat complexity in Shell Lake should be strongly encouraged. Input of coarse woody debris, protection/promotion of aquatic vegetation, and maintenance or restoration of 35 foot vegetative buffers are some examples of work that can increase habitat complexity.
9. Exotic species monitoring and control programs should continue. Efforts to keep aquatic invasive species out of a waterbody are much more effective than controlling these species once they are established.

Acknowledgements

I would like to thank Jamison Wendel, my predecessor, who began this report. I would like to thank Kent Bass, Eric Berge, and the Treaty Assessment crew who conducted the field work, aged fish, and entered data during this study. Terry Margenau and Jeff Kampa provided a critical review of the manuscript.

Literature Cited

Beard, T. D., Jr., S. W. Hewett, Q. Yang, R. M. King, and S. J. Gilbert. 1997. Prediction of angler catch rates based on walleye population density. North American Journal of Fisheries Management 17 (4): 621-627.

Benike, H. 2005. Changes in the Gamefish Community of a Small Northwestern Wisconsin Lake Over a 25-Year Period, Ward Lake, Polk County, Wisconsin, Wisconsin Department of Natural Resources, Internal Fisheries Management Report. Barron Field Office.

Benike, H. 2010. Balsam Lake Treaty Assessment Survey, Polk County, Wisconsin. Wisconsin Department of Natural Resources, Internal Fisheries Management Report, Barron Field Office.

Carlson, R. 1977. A trophic state index for lakes. Limnology and Oceanography 22(2):361-369.

Casselman, J.M. 1990. Growth and relative size of calcified structures of fish. Transactions of the American Fisheries Society 119:673-688.

Cichosz, T.A. 2014. Wisconsin Department of Natural Resources 2012-2013 Ceded Territory Fishery Assessment Report. Wisconsin Department of Natural Resources. Administrative Report 75, Madison.

Cole, A.J. 2014. Big Round Lake Fisheries Assessment, 2012-2013, Polk County, Wisconsin Department of Natural Resources, Internal Fisheries Management Report, Barron Field Office.

Faust, M. D. 2011. Effect of harvest mortality on muskellunge size structure in Wisconsin's ceded territory. Master's Thesis. University of Wisconsin, Stevens Point.

Fitzgerald, T.J., T.L. Margenau, and F.A. Copes. 1997. Muskellunge scale interpretation: the question of accuracy. North American Journal of Fisheries Management 17:206-209.

Hanson, D.A. 1986. Population characteristics and angler use of muskellunge in eight northern Wisconsin Lakes. Pages 238-248 *in* G. E. Hall, editor. Managing muskies. American Fisheries Society, Special Publication 15, Bethesda, Maryland.

Hanson, D.A. and T.L. Margenau. 1992. Movement, habitat selection, behavior, and survival of stocked muskellunge. North American Journal of Fisheries Management. 12:474-483.

Johannes, S.J. 1978. 1977 Comprehensive survey, Shell Lake, Washburn County. Wisconsin Department of Natural Resources, Internal Fisheries Management Report, Spooner Field Office.

Lillie, R.A., S. Graham, and P. Rasmussen. 1993. Trophic state index equations and regional predictive equations for Wisconsin lakes. Bureau of Research – Wisconsin Department of Natural Resources, Research Management Findings, Number 35.

Margenau, T.L. and S.P. Avelallemant. 2000. Effects of a 40-Inch minimum length limit on muskellunge in Wisconsin. North American Journal of Fisheries Management, 20:986-993.

Neumann, R. M., C. S. Guy, and D. W. Willis. 2013. Length, weight, and associated indices. Pages 637-676 in A. V. Zale, D. L. Parrish, and T. M. Sutton, editors. Fisheries techniques, 3rd edition. American Fisheries Society, Bethesda, Maryland.

NOAA. National Oceanic and Atmosphere Administration. 2014. NOAA online weather data-Spooner Exp. Farm, Spooner. Available from: http://www.weather.gov/climate/xmacis.php?wfo=dlh

Ricker, W.E. 1975. Computation and interpretation of biological statistics of fish populations. Bulletin. Fisheries Research Board of Canada 191. 382p.

Wendel, J. 2011. Yellow and Little Yellow Lakes Fishery Survey, Burnett County, Wisconsin 2008-2009. Wisconsin Department of Natural Resources. Internal Fisheries Management Report. Spooner Regional Office.

Wendel, J. 2013. Big McKenzie Lake Fishery Survey, Burnett County, Wisconsin 2012. Wisconsin Department of Natural Resources. Internal Fisheries Management Report. Spooner Regional Office.

WDNR 2013. Citizen monitoring lake water quality database. Available from: http://dnr.wi.gov/lakes/CLMN/about.html.

Table 1A. Age structure of female walleyes captured during 2013 spring survey on Shell Lake, Washburn County, Wisconsin.

Age	Number Aged	Average Length	Minimum Length	Maximum Length
5	2	18.3	17.8	18.8
6	5	17.6	16.9	18.7
7	6	18.7	17.4	20.3
8	18	19.6	18.2	21.6
9	2	20.7	20.0	21.3
10	0	NA	NA	NA
11	1	21.7	21.7	21.7

Table 1B. Age structure of male walleyes captured during 2013 spring survey on Shell Lake, Washburn County, Wisconsin.

Age	Number Aged	Average Length	Minimum Length	Maximum Length
2	1	11.2	11.2	11.2
3	1	12.3	12.3	12.3
4	2	14.4	14.2	14.6
5	1	14.6	14.6	14.6
6	0	NA	NA	NA
7	4	17.1	15.3	18.5
8	28	16.9	15.4	19.2
9	3	17.0	15.4	18.2
10	2	19.1	18.5	19.6

Table 2. Northern pike PSD and PSD-P values and catches per net night from fish collected during spring spawning population assessments on Shell Lake, Washburn County. Only fish captured during spring fyke netting 2012 were included in analyses.

Parameter	2012	2003	1999	1977
PSD	29	28	32	12
PSD-P	4	1	3	2

Table 3. Total catch by species in mini-fyke net samples in 1999 and 2013.

Fish Species	1999	2013
Black Bullhead	428	1
Black Crappie	2	-
Bluegill	5,027	163
Bluntnose Minnow	75	18
Brown Bullhead	1	-
Central Mudminnow	1	-
Hornyhead Chub	2	-
Johnny Darter	4	1
Largemouth Bass	100	23
Logperch	5	4
Muskellunge	1	-
Northern Pike	1	-
Pumpkinseed	161	-
Rock Bass	44	27
Smallmouth Bass	43	72
Spottail Shiner	3	71
Walleye	1	-
White Sucker	3	1
Yellow Bullhead	5	-
Yellow Perch	102	6,577

Table 4. Projected angler pressure (angler hrs) and angler hours/acre during the past three Wisconsin DNR creel surveys for Shell Lake.

Fishing Season	1994-1995	1999-2000	2013-2014
Open Water Projected Pressure	20,751	23,138	14,389
Ice Projected Pressure	5,739	2.460	676
Total Projected Pressure	26,489	25.597	15,066
Angler Hours/Acre	10.3	9.9	5.8

Table 5. Tribal exploitation rates, recreational exploitation rates, and total exploitation rates (%) for walleye from 1994, 1999, and 2013 for Shell Lake.

Fishing Season	Tribal	Recreational	Total
1994-1995	0.4	3.7	4.1
1999-2000	0.4	2.0	2.4
2013-2014	17.4	3.1	20.6

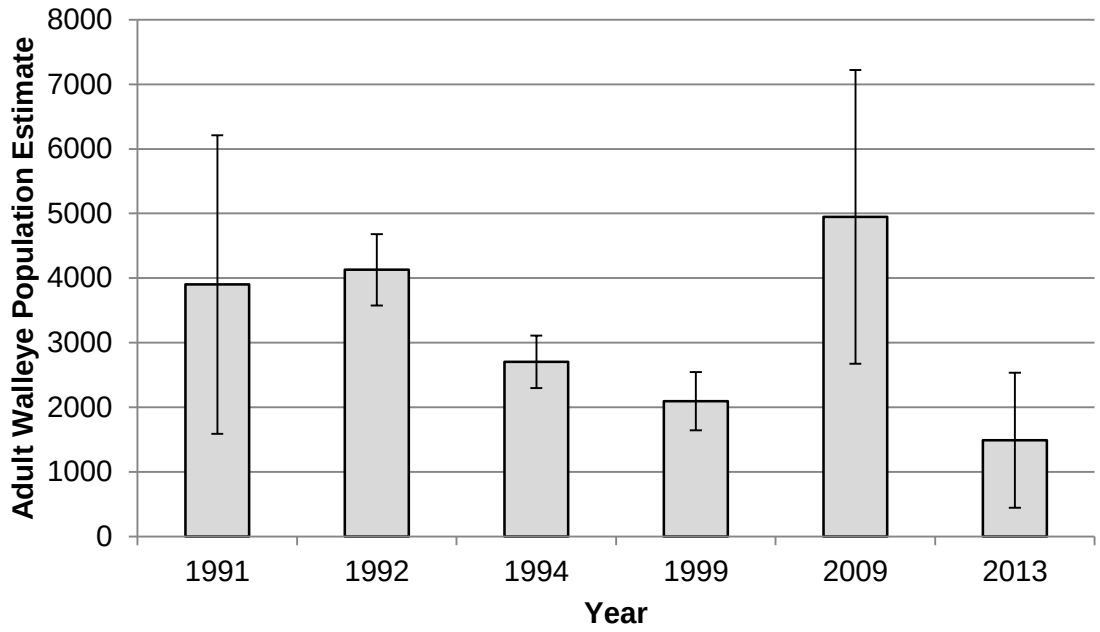

Figure 1. Adult walleye population estimates (95% confidence intervals) for Shell Lake, Washburn County, Wisconsin.

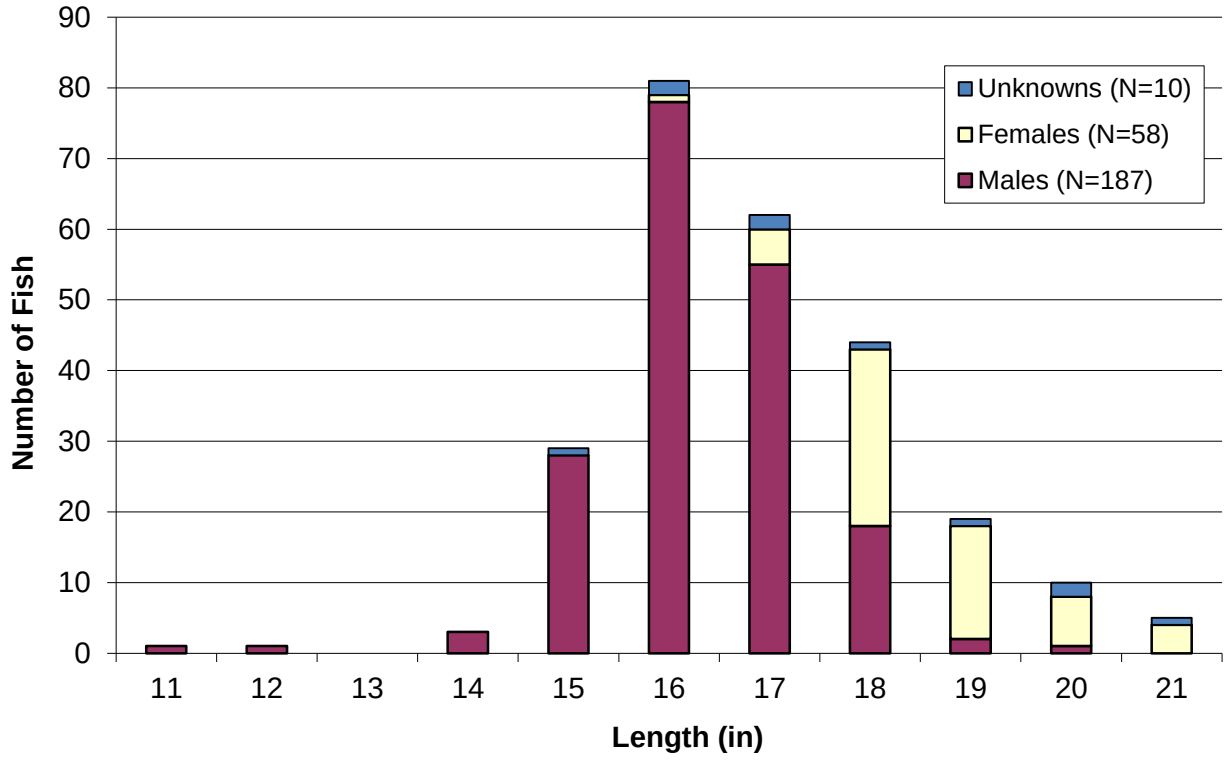

Figure 2. Length frequencies of adult walleyes captured during spring 2013 sampling in Shell Lake, Washburn County, Wisconsin (n=255).

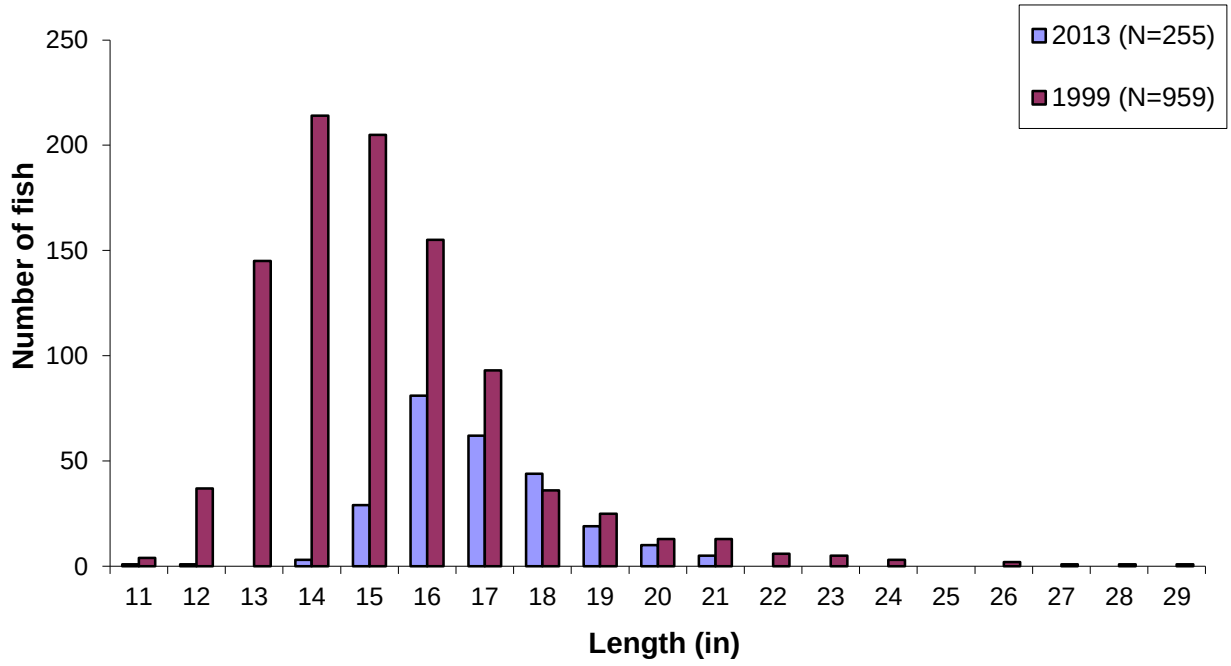

Figure 3. Length frequencies of spawning walleyes captured in spring 2013 and 1999 in Shell Lake, Washburn County, Wisconsin.

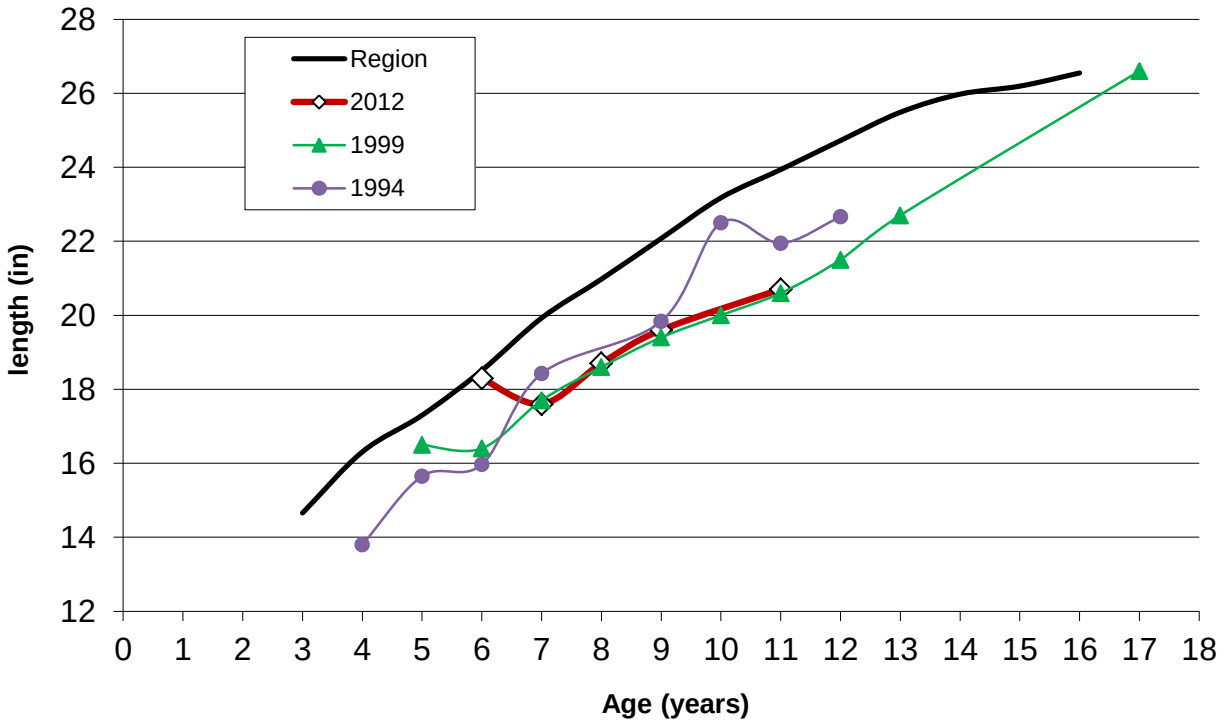

Figure 4. Mean lengths at age for female walleyes captured during spring surveys on Shell Lake, Washburn County, Wisconsin. Regional averages are displayed for comparison.

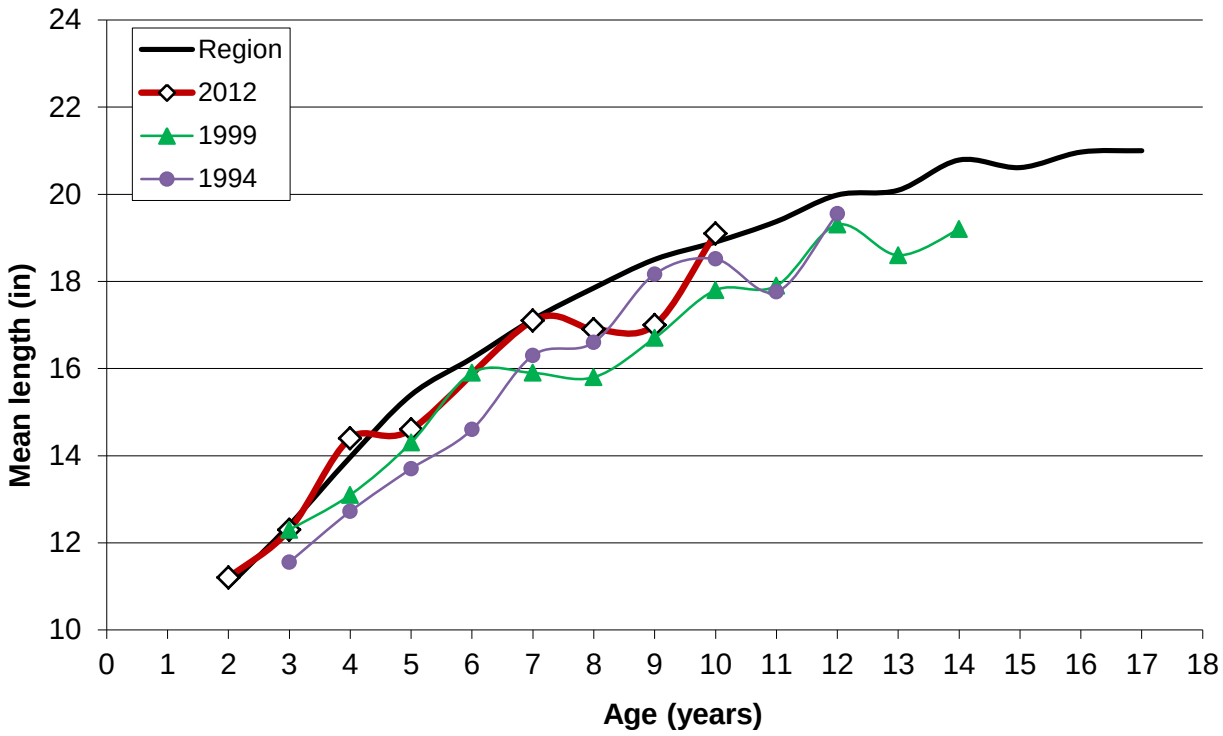

Figure 5. Mean lengths at age for male walleyes captured during spring surveys on Shell Lake, Washburn County, Wisconsin. Regional averages are displayed for comparison.

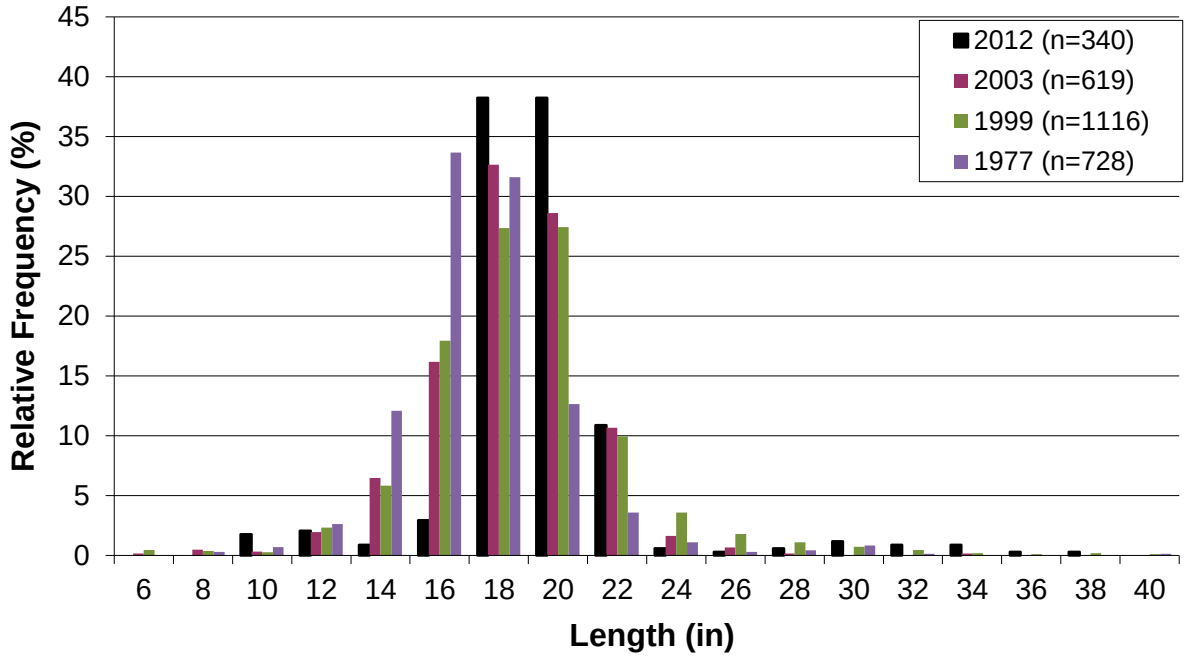

Figure 6. Relative length frequency of northern pike captured in Shell Lake, Washburn County, Wisconsin in spring 1977, 1999, 2003, and 2012 surveys.

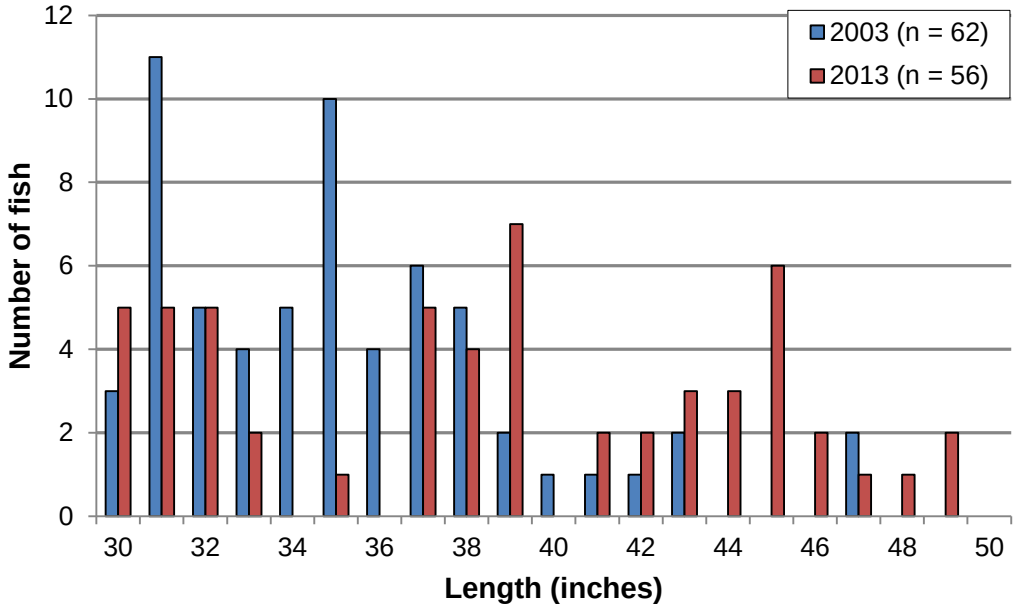

Figure 7. Length frequency of muskellunge captured in Shell Lake, Washburn County, Wisconsin in spring 2002-2003 and 2012-2013.

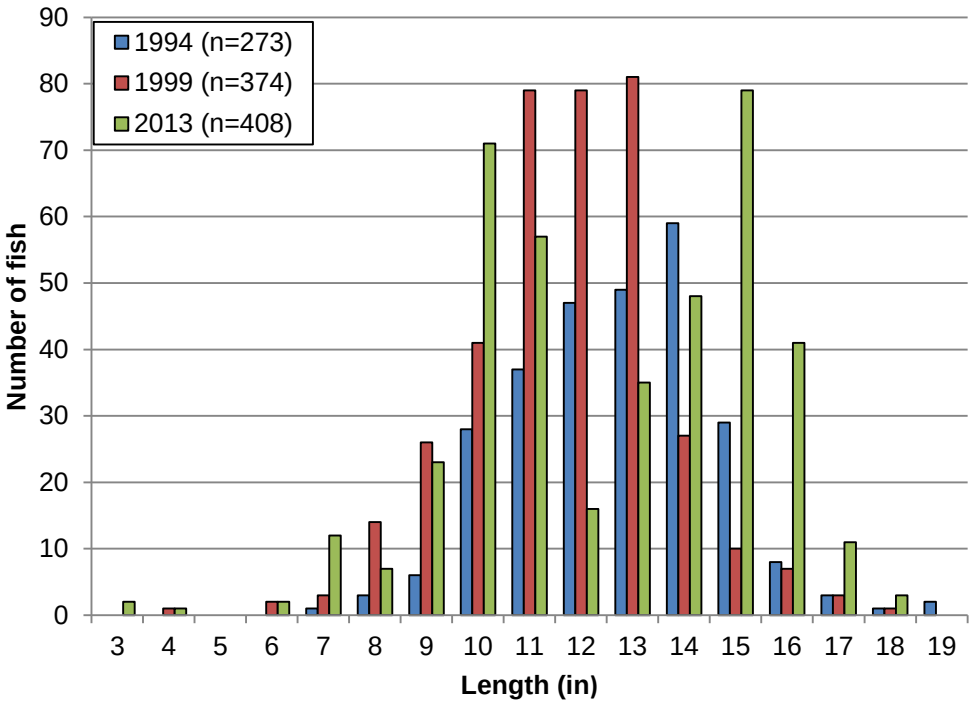

Figure 8. Length frequency of smallmouth bass captured in Shell Lake, Washburn County, Wisconsin in spring 1994, 1999, and 2013 surveys.

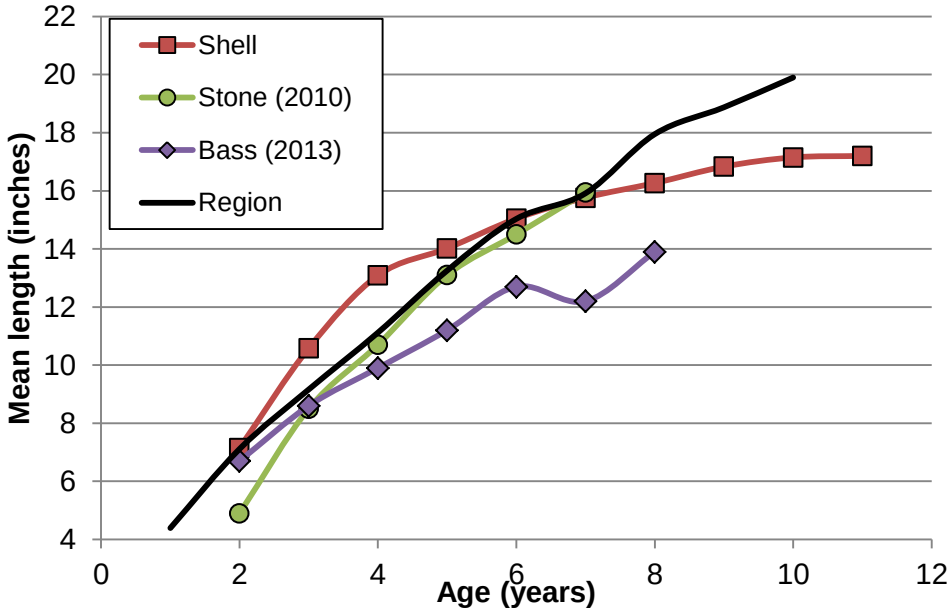

Figure 9. Mean length-at-age for smallmouth bass in Shell Lake, Stone Lake, and Bass-Patterson Lake compared with the Northern Region Average.

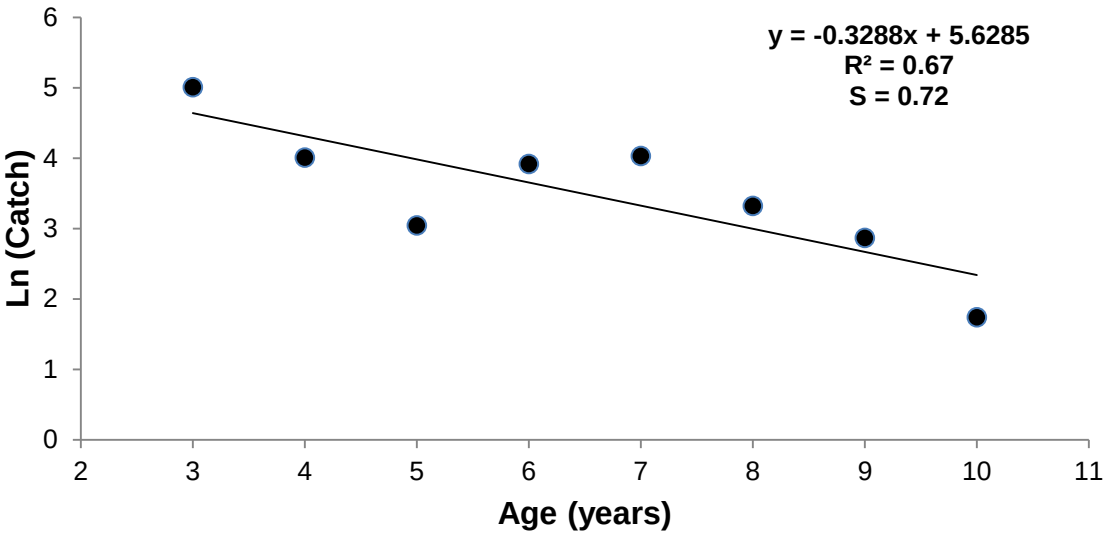

Figure 10. Total annual survival rate of smallmouth bass for Shell Lake, Washburn County in 2013.

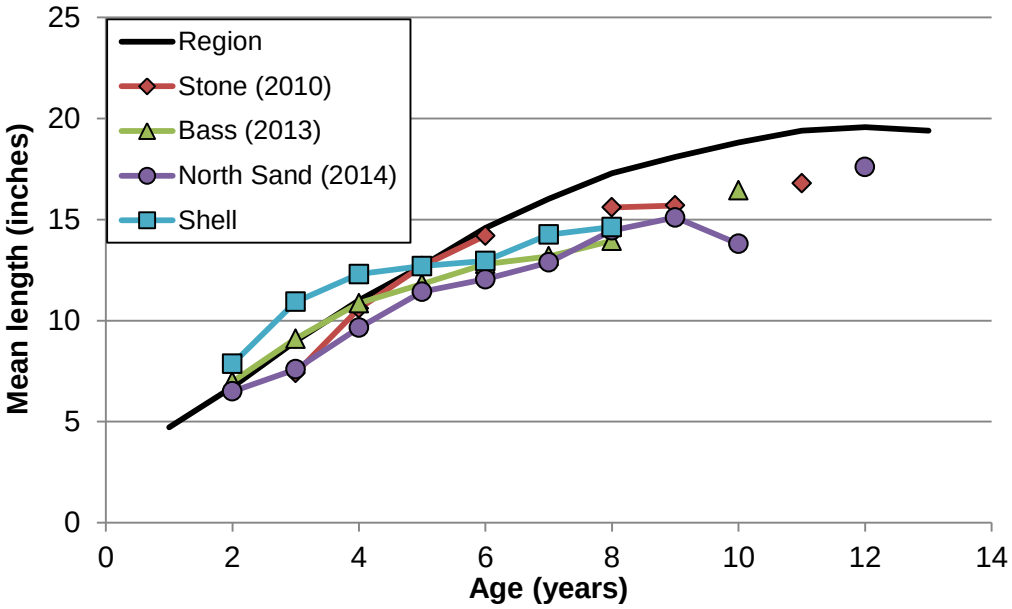

Figure 11. Mean lengths at age for largemouth bass captured during spring surveys on Shell Lake, Washburn County, Wisconsin. Northern region average and area seepage lakes are compared.

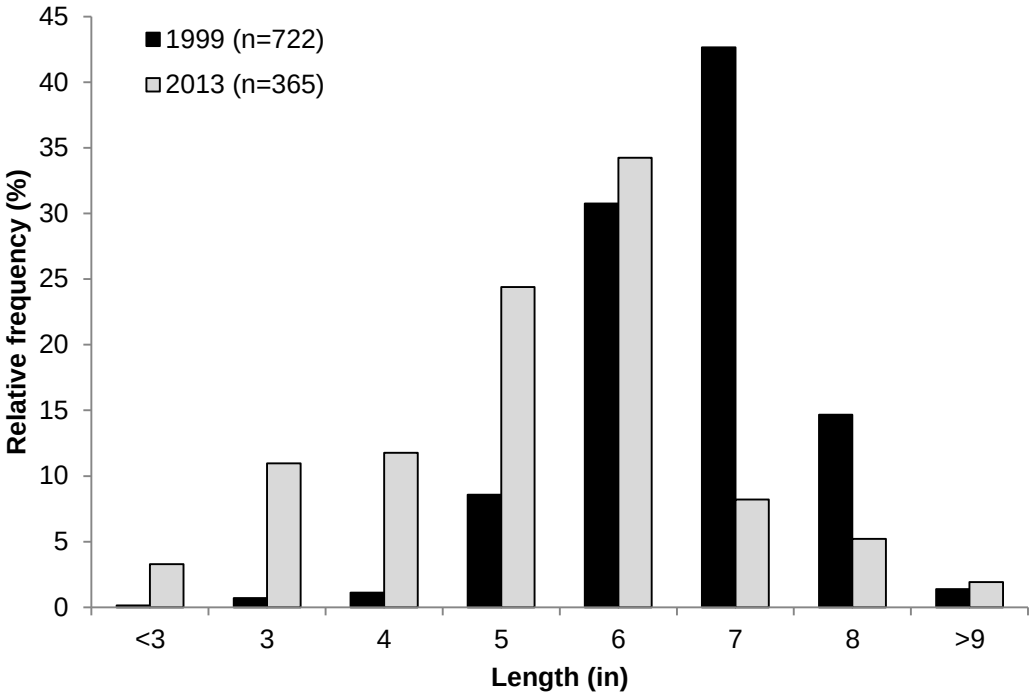

Figure 12. Length frequency of bluegill captured in Shell Lake, Washburn County, Wisconsin 1999 and 2013.

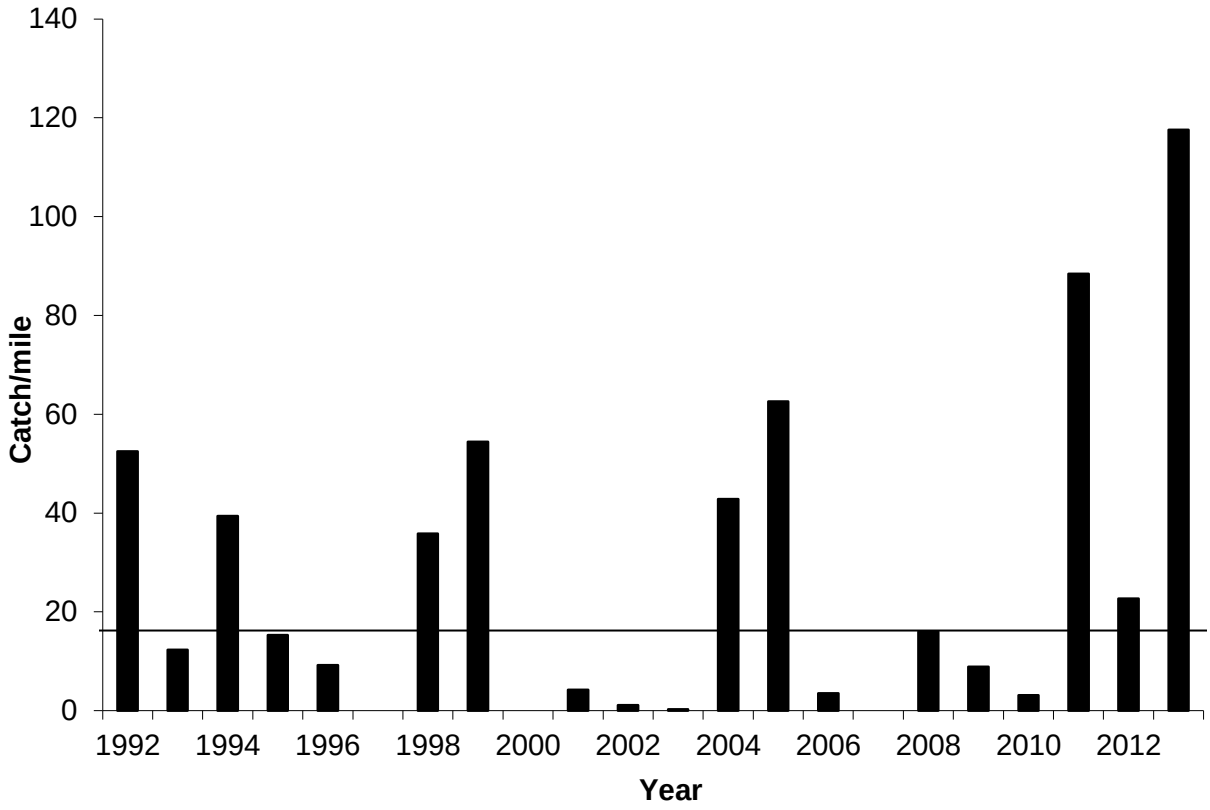

Figure 13. Young of year (YOY) walleye relative abundance determined by fall electrofishing surveys on Shell Lake, Washburn County, Wisconsin. The solid horizontal line indicates the modal catch of 16 YOY walleye per mile in northern Wisconsin lakes supported by natural reproduction. Fall surveys were not conducted on Shell Lake in 1997, 2000, and 2007.

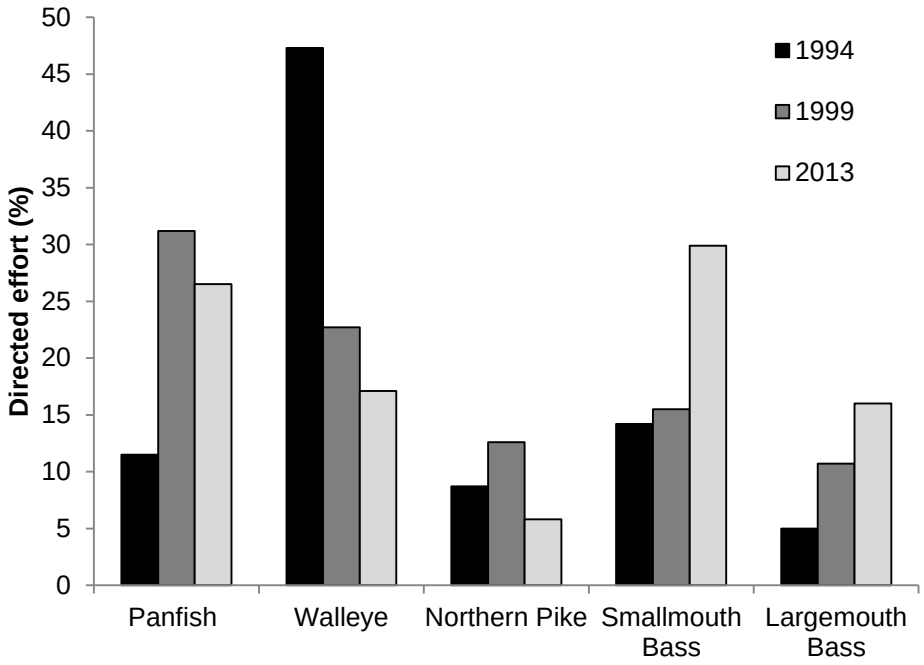

Figure 14. Estimated species directed effort (%) for sportfish and panfish in Shell Lake for 1994, 1999, and 2013 fishing seasons. Panfish include bluegill, black crappie, rock bass, yellow perch and pumpkinseed.

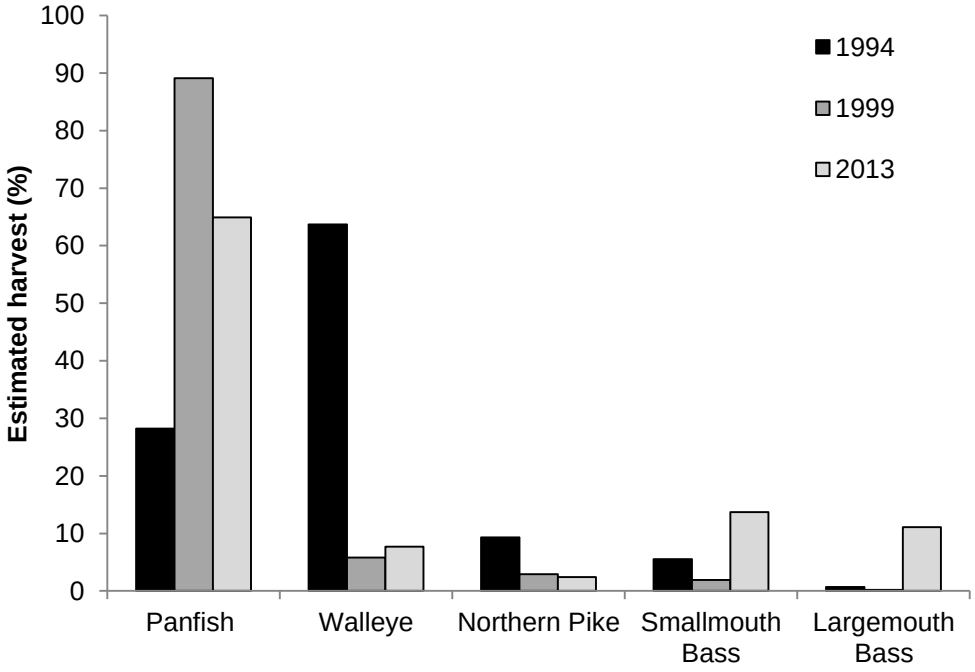

Figure 15. Estimated harvest (%) of sportfish and panfish in Shell Lake, Washburn County, Wisconsin for 1994, 1999, and 2013 fishing seasons. Panfish include bluegill, black crappie, rock bass, yellow perch, and pumpkinseed.

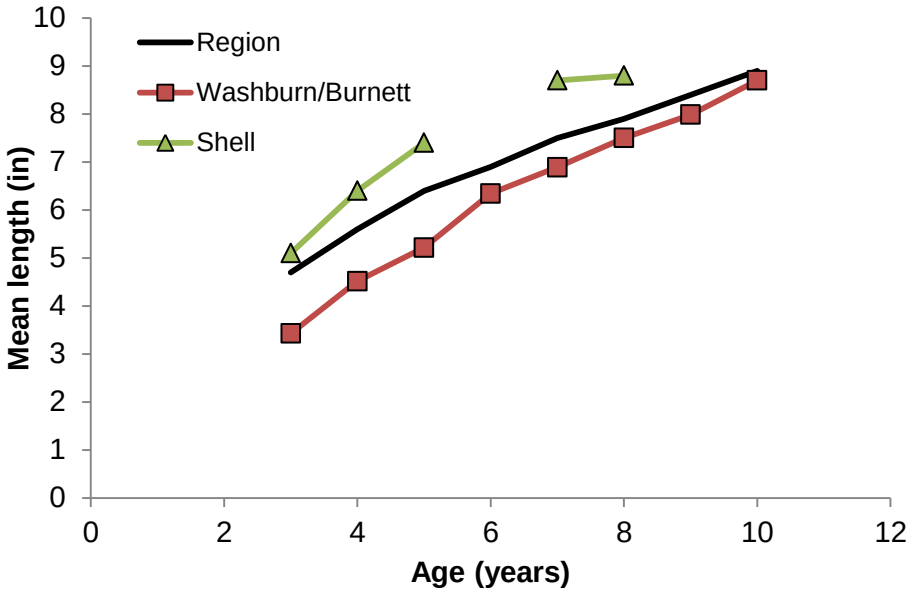

Figure 16. Mean lengths at age for bluegill captured during 2013 spring surveys on Shell Lake, Washburn County, Wisconsin. Northern Region, Washburn, and Burnett county averages are provided for comparison.

Appendix Table 1. Fish stocking records for Shell Lake, Washburn County, Wisconsin, 1998-2013.

Year	Species	Number Fish Stocked	Mean Fish Length (in)
1998	Muskellunge	2,500	12.0
2000	Muskellunge	1,776	12.1
2002	Muskellunge	1,284	10.7
2004	Muskellunge	1,288	10.9
2007	Muskellunge	1,290	12.2
2009	Muskellunge	2,498	10.0
2011	Muskellunge	1,290	9.7
2013	Muskellunge	1,185	11.5

Appendix Table 2. General Fishing Regulations for Shell Lake, Washburn County, Wisconsin, in 2013.

Fish Species	Open Season	Daily Limit	Minimum Length (in)
Walleye	May 05-March 03	3	1>14
Largemouth and Smallmouth Bass	May 05-March 03	5	14
Muskellunge	May 26-November 30	1	40
Northern Pike	May 05-March 03	5	NONE
Panfish	Open Season Year Round	25	NONE

Appendix Table 3. Size cutoffs used to determine whether primary or secondary fin clips should be applied to gamefish when gender could not be determined. TC indicates top caudal fin clip.

Fish Species	Primary Fin Clip	Secondary Fin Clip
Walleye	≥15 in	≥ 7" < 15" (TC Clip)
Bass	≥8 in	< 8" (TC Clip)
Muskellunge	≥30 in	Immature fish < 30 in (TC Clip)
Northern Pike	≥12 in	< 12" (TC Clip)

Appendix Table 4. Values used in proportional stock density calculations.

Fish Species	Stock Size (in)	Quality Size (in) PSD	Preferred Size (in) PSD-P
Largemouth Bass	8	12	15
Northern Pike	14	21	28
Smallmouth Bass	7	11	14
Walleye	10	15	20

For example: A sample of walleye has 100 fish longer than 10 inches (stock size), with 50 of those fish being longer than 15 inches (quality), and 25 of those fish being longer than 20 inches (preferred). The PSD (quality/stock) would be 50 and the PSD-P (preferred/stock) would be 25.